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by him from M. Moissant, of the Imperial School of Mines, Paris, giving an account of a new gas-engine, invented by M. Lenoir of that city. He also gave some further details concerning the frozen well, at Brandon, Vermont.

Four hundred and eighty-sixth meeting.

September 11, 1860. — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Horsford, chairman of the Rumford Committee, laid upon the table the dies for the Rumford medal, received from the United States Mint, in pursuance of a vote of the Academy at the last Anniversary Meeting. And they were deposited in the iron safe of the Academy.

Professor Horsford submitted a memoir on the relations of the salts of zinc and alumina to those of soda and potassa.

Messrs. Charles W. Eliot and Frank H. Storer presented the two following notes, supplementary to their Memoir upon the Impurities of Commercial Zinc.

I. On the Amounts of Lead contained in some Silver Coins.

From our experiments upon the impurities of commercial zinc,* we found that this metal almost invariably contains lead. In the preparation of silver at the United States Mint, zinc is used for the purpose of reducing chloride of silver,† and a sample of zinc similar to that used at the Mint, which we examined, yielded half of one per cent of lead. The question naturally suggested itself whether lead might not thus find its way into American silver coin, and to determine this point we have analyzed several American coins, as specified in the following table; for the sake of comparison we subsequently examined the other coins therein enumerated.

* *Memoirs of the American Academy*, 1860 [N. S.], VIII. 57.

† Booth and Morfit's *Smithsonian Report on Recent Improvements in the Chemical Arts*, (Washington, 1851,) p. 56. Compare Wilson's Report on the New York Industrial Exhibition, in *Dingler's Polyt. Journal*, 1855, CXXXV. 119.

TABLE.

(1.) Kind of Coin.	(2.) Weight of Coin taken. Grammes.	(3.) Weight of BaO, SO ₃ found. Grammes.	(4.) Weight of Pb cor- responding to SO ₃ in the BaO, SO ₃ of column (3).	(5.) Corre- sponding per cent of Lead in the Coin.	(a.) * Weight of PbO, SO ₃ found. Grammes.	(b.) * Corre- sponding weight of Pb.	(c.) * Corre- sponding per cent of Lead in the Coin.
1 American half-dollar of 1824.	13.2936	0.0465	0.0412	0.3100	0.0480	0.0327	0.2462
20 Ameri- can five-cent pieces of 1853.	24.2630	0.0571	0.0507	0.2090	0.0555	0.0379	0.1560
10 Ameri- can five-cent pieces of 1854.	12.1980	0.0314	0.0278	0.2282	0.0270	0.0185	0.1513
2 American twenty-five- cent pieces of 1858.	12.4097	0.0322	0.0286	0.2305	0.0310	0.0273	0.2200
"Fine sil- ver"† from the U. S. As- say Office in New York, 1860.	30.6405	0.0557	0.0494	0.1611	0.0655	0.0447	0.1457
1 Spanish dollar of 1793. Carolus IV.	27.0130	0.0170	0.0151	0.0558	0.0129	0.0088	0.0326
1 Mexican dollar of 1829.	27.2265	0.0127	0.0118	0.0434			
2 English shillings of 1816.	10.4597	0.0537	0.0507	0.4847	0.0590	0.0422	0.3846
1 French five-franc piece of 1852. Napoleon III.	24.9725	0.1135	0.1069	0.4282	0.1296	0.0886	0.3546

* Columns (a), (b), and (c) contain the results of a supplementary series of experiments, made merely to control the results given in columns (4) and (5). (*Vid. infra.*)

† The solution of this fine silver in nitric acid became blue when neutralized with ammonia. The filtrate from the mixed precipitate of sulphate of lead and gold (see p. 56) contained a decided trace of copper and a fainter trace of iron. The solution of sulphate of soda, from which the sulphuric acid of col. (3) was

On the supposition that the zinc used in the reduction of the silver is the source of the lead in the American coin, it is easy to calculate the amount of lead which would thus find its way into the coin, since the quantity of zinc used in reducing a given weight of silver, and the per cent of lead which that zinc may be expected to contain, are both known quantities. Professor Booth* says that an excess of zinc is required to insure total and rapid reduction, and Wilson† states, that two equivalents of zinc are used, in practice, for each equivalent of silver. Our memoir, already cited, gives the per cents of lead found in two specimens of Vieille Montagne zinc. The standard of the American silver coin is $\frac{9}{10}$ silver and $\frac{1}{10}$ copper, and the weight of fifty cents' worth of this alloy, in either half-dimes, dimes, quarters, or a half-dollar, has been 192 grains = 12.433 grammes, since the year 1853.‡

Fine silver in the half-dollar, ...	11.190 gram.
Zinc used in reducing 11.19 gram. silver, . .	6.742 “
Amount of lead in 6.742 gram. zinc, if the zinc	
contains 0.292 per cent of lead, §	0.0197 “
Amount of lead in 6.742 gram. zinc, if the zinc	
contains 0.494 per cent of lead, §	0.0333 “

If zinc of the best quality (containing 0.292 per cent. of lead) had been used, the silver coin would have contained 0.158 per cent of lead; if the second quality (containing 0.494 per cent of lead) has been employed, the coin may contain 0.268 per cent of lead. Between these two limits all our determinations of lead in American silver will be found to lie.

In offering this explanation of the occurrence of lead in American silver coin, we would by no means affirm that the zinc is the exclusive source of this impurity, for it is not at all improbable that a portion of the lead is derived from the leaden vats in which the reduction of the

determined, exhibited a slightly yellowish-light-brown color, nothing similar to which occurred in any of the other experiments. A slight black residue remained when this silver was dissolved in nitric acid, and a trace of gold was detected in the residue described on p. 59.

* *Loc. cit.*

† *Loc. cit.*

‡ Brightly's Dig. Laws U. S., for Standard, Title *Coinage*, § 3; for Weights, Title *Coinage*, § 13.

§ See our Memoir in Mem. Amer. Acad. [N. S.], VIII. 61, Table I.

chloride of silver is effected, or from the sulphuric acid which is used to excite the reaction.

The method of analysis employed was as follows. The coin having been dissolved in moderately strong, pure, nitric acid, the cooled solution was treated with an excess of a solution of pure caustic ammonia, added by small portions,—no notice being taken of the small, dark-colored residue (AgS , etc.) insoluble in nitric acid. The precipitated oxide of silver was re-dissolved in nitric acid, enough of the latter being added to render the solution distinctly acid. The whole was then heated in a water-bath, and a strong solution of pure chloride of ammonium added, until chloride of silver was no longer precipitated, care being taken to avoid adding an unnecessary excess of chloride of ammonium. It will be seen, that the chloride of silver was thus precipitated in presence of a large excess of nitrate of ammonia; and since chloride of lead is readily soluble in a solution of nitrate of ammonia,* any lead which the coin may have contained would remain in solution. It may be mentioned in passing, that the small amount of chloride of silver which, as has already been stated by Mulder,† is retained in solution by nitrate of ammonia,—especially by hot solutions,—did not interfere in the least with the subsequent steps of the analysis, or in any way to influence the amount of lead obtained. The precipitated chloride of silver was collected upon a filter, and thoroughly washed with hot water, the lumps of chloride of silver being broken down as much as possible with a glass rod. The filtrate and wash waters were evaporated in a porcelain dish to the consistence of a thin syrup, and then transferred to a flask of hard German glass, in which the evaporation was continued until the nitrate of ammonia had been entirely destroyed. This operation requires care in the application of the heat, lest violent decomposition of the nitrate of ammonia ensue, and portions of the substance be projected from the flask. When properly conducted, the process goes on tranquilly, and no loss occurs. The residue, consisting of nitrate of copper, together with nitrate of lead, and more or less gold, should be washed with hot water into a porcelain dish, where it is mixed with a slight excess of pure sulphuric acid. It may be necessary to use a little nitric acid to dissolve the last portions of the substance in the flask. The mixture

* Bolley, Ann. Ch. u. Pharm., 1854, XCI. 115.

† Die Silber-Probirmethode, (Leipzig, 1859,) p. 28.

is then evaporated over the water-bath until it has become almost entirely dry, — or until it no longer exhibits any tendency to effervesce; it is then somewhat more strongly heated on a sand-bath, until all the free sulphuric acid has been driven off, that is, until fumes of sulphuric acid are no longer perceptible. The necessity of thoroughly evaporating this mixture cannot be too strongly insisted upon, for a solution of gold in sulphuric acid * is formed when the mixed nitrates, etc. are treated with sulphuric acid, and unless this compound be entirely destroyed by heating, it will be subsequently decomposed when water is added, and give rise to a precipitate of metallic gold, in a condition so finely divided that it cannot be separated by filtering. The occurrence of this precipitate would ruin the analysis. We at first sought to prevent the formation of this solution of gold in sulphuric acid, by heating very strongly the residue left in the flask after all the nitrate of ammonia had been decomposed, until the escape of nitrous fumes had entirely ceased, and the nitrate of copper was decomposed. We then treated the mass with pure dilute nitric acid, and filtered off the solution from the gold which had been deposited and from any chloride of silver which had been dissolved by the nitrate of ammonia, with the intention of determining the lead directly, by precipitating it as sulphate from this solution after evaporation with sulphuric acid. It was found, however, that a large portion of the gold-salt escaped decomposition in the flask, the yellow solution of sulphate of gold being formed almost as abundantly after this treatment as when the flask was not heated so strongly; and since in this method there is great risk of fracturing the vessel from drops of acid condensing in its neck and flowing down upon the hot portion, it can in no wise be recommended. A perfectly dry mixture of sulphate of copper, sulphate of lead, and metallic gold having been obtained, it is treated with distilled water, — a considerable quantity of the latter being added at once, and the mixture quickly stirred to prevent the sulphate of copper from forming a hard cake as it becomes hydrated. As soon as the sulphate of copper is completely dissolved, a small quantity of pure sulphuric acid is to be added to the solution, and the latter set aside for at least forty-eight hours. The precipitate, consisting of sulphate of lead and metallic gold, was then collected upon a small Swedish filter and washed, first with dilute sulphuric acid to remove the sulphate of cop-

* Compare Pelletier, *Ann. Ch. et Phys.* [2], XV. 12.

per, and subsequently with alcohol, until no trace of free sulphuric acid remained. After drying, the precipitate of sulphate of lead and gold, with the filter cut into small pieces, was transferred to a beaker glass, and the whole was then digested with pure bicarbonate of soda* (prepared from the oxalate), during at least forty-eight hours. The sulphate of soda formed by this operation was then filtered off from the carbonate of lead and metallic gold, and the amount of sulphuric acid which it contained determined by precipitation with chloride of barium in the usual way. From the amounts of sulphate of baryta thus obtained, recorded in column (3) of the table, the amounts of lead (col. 4) in the mixed precipitates of sulphate of lead and gold were calculated.

The carbonate of lead, mixed with bits of paper and gold, above mentioned, was now dissolved in dilute nitric acid, the solution evaporated with sulphuric acid until all the nitric acid had been expelled, subsequently treated with water acidified with sulphuric acid, and, after standing for forty-eight hours, collected upon a tared filter, washed with dilute sulphuric acid and alcohol, dried at 100°, and weighed. The results may be found in column (a) of the table.

The re-agents used in the foregoing operations were all chemically pure. A special experiment was moreover made, in which portions of the nitric acid, ammonia, chloride of ammonium, and sulphuric acid used, twice as large as any which were actually employed in the analysis of either of our samples of coin, were evaporated together, and subjected to a course of treatment identical with that which the solutions of coin were forced to undergo; but not a trace of sulphate of lead, or of any precipitate, other than a few light and utterly insignificant floating flocks, probably alumina, could be detected as the result of this trial.

That our process is sufficiently accurate to exhibit *all* the lead which the samples of coin examined really contained, we do not think probable. All of the sources of error to which the process, when properly conducted, is subject, tend to cause a slight loss of lead. Thus, in the first place, it is scarcely possible that the last traces of chloride of lead can be removed by washing from the caseous precipitate of chloride

* See Fresenius, *Anleitung zur Quantitativen Analyse*, (Braunschweig, 4^{te} Aufl. 1858,) p. 286, § 132, II. b. β .

of silver,* which precipitate is in enormous mass as compared with the amount of chloride of lead; and again, the first precipitate of sulphate of lead, mixed with gold, which is obtained after evaporation with sulphuric acid, occurs in so finely divided a state, that it is exceedingly difficult to prevent loss by the passing of a portion of it through the pores of the filter upon which the precipitate is collected. To one unused to the process, it might seem as if the last traces of sulphuric acid could hardly be removed from this precipitate by washing with alcohol. We have satisfied ourselves, however, that this is easily effected, and that this seeming source of error is, in reality, entirely insignificant; at any rate, the results given in columns (a), (b), and (c) are in no way influenced by this imaginary error. It may not be amiss to observe, that we have been particularly scrupulous with regard to the treatment of the above-mentioned precipitate, having in every instance continued to wash it with alcohol long after any reaction of sulphuric acid could be detected. It should also here be stated, that the results in which we ourselves place the most confidence are those obtained by determining the amount of sulphuric acid in the mixed precipitate of sulphate of lead and gold (see cols. (3), (4), and (5) of the table), for columns (a), (b), and (c) contain the results of a secondary process liable to all the accumulated errors of a long series of operations; moreover, the final precipitate of sulphate of lead is very finely divided, and, like the first precipitate, liable to pass through the pores of the filter, as has been previously explained. This second series of experiments has been carried out, not from any expectation that the results would closely agree with those of the first series, but merely to control the latter to a certain extent, and to remove any objection which might be made to the indirect method by which they were obtained. Since the possible inaccuracies of the process tend to a loss of lead, we are confident that the amounts of lead we have obtained are in no instance greater than those really existing in the coin.

The precipitates of pure sulphate of lead (column (a) of the table) were, in every instance, reduced on charcoal with carbonate of soda, and the button of lead obtained carefully tested for silver, of which none could be detected in any case; nor did the metal exhibit any reactions, other than those of pure lead.

The residue of gold and filter paper left after dissolving the car-

* Compare Mulder, *op. cit.*, p. 217.

bonate of lead in nitric acid for the final lead determination, was in each case incinerated, and then fused with carbonate of soda before the blowpipe. A distinct button of metallic gold was obtained in every instance. The amount of gold obtained varied, however, to a very considerable extent: it was abundant in the American and Spanish coin, less was observed in the English and Mexican, and but little in the French coin or the American fine silver.*

The silver of the French coin was undoubtedly prepared by the sulphuric-acid process,† in which the granulated alloy of silver, gold,

* Besides the quantitative analyses recorded above, which have been made by this method, it should be mentioned, that in several qualitative experiments upon American coins, by the method as described or slightly modified, indications of lead were obtained in every instance. The same remark is true of two qualitative analyses, — one of a dime and another of a quarter-dollar, — made as follows: the coin having been dissolved in nitric acid, and the insoluble black residue of sulphide of silver and a little gold separated by filtering, the solution was mixed with pure acetate of soda (see Fresenius, *op. cit.*, p. 428, § 163, 1. γ) to prevent precipitation of chloride of lead in subsequent operations, and the whole heated over the water-bath; the silver was then precipitated with dilute chlorhydric acid, and the chloride of silver collected upon a filter and washed. Through the filtrate sulphuretted hydrogen was passed, the mixed sulphide of copper, lead, and gold collected upon a filter, treated with nitric acid, the acid solution evaporated to dryness, the residue taken up with water, and the solution filtered; in the filtrate lead was detected, while the residue contained gold.

With regard to this residue of gold, which has also been alluded to in the text, it should be remarked that it has been entirely neglected by many analysts who have published determinations of the amounts of gold in various silver coins. Indeed, it would appear as if the fact were not generally known to chemists, that nitric acid can dissolve a little gold (as it can platinum), when an alloy containing a small quantity of gold is treated with this acid (compare Mulder, *op. cit.*, p. 159). Another common error of analysts has been, to class as “gold” the dark-colored residue which is usually left when silver coin is dissolved in dilute nitric acid. This precipitate does, in fact, generally contain a little gold, though in our own experiments by far the larger portion of this metal passed into solution in the nitric acid, and was separated at a subsequent stage of the analysis, as has been described; Gay Lussac (*Ann. Ch. et Phys.*, 1836, [2.] LXIII. 334) long ago showed that it is principally composed of sulphide of silver; to which fact attention has also been called by Mulder, in his excellent little treatise, just cited, p. 178.

† See D’Arcet in *Dingler’s Polyt. Journ.*, 1828, XXVIII. 3; from *Annales Mensuelles*, Mai, 1827, p. 131. Also, *Ure’s Dictionary of Arts, &c.*, 4th edit., (Boston, 1853,) II. 543. Dumas’s *Traité de Chimie Appliquée aux Arts*, (Paris, 1833,) IV. 464.

copper, &c. is dissolved in hot concentrated sulphuric acid, and the silver subsequently precipitated, by means of metallic copper, from a somewhat diluted hot solution of the sulphate of silver thus obtained. Since ordinary commercial sulphuric acid* is used in this operation, it is not strange that a portion of the lead with which it is contaminated should be transferred to the silver. The lead salt is perhaps reduced by the metallic copper in the manner so well described by Odling, in his memoir "On the Reciprocal Precipitations of the Metals."† It is, moreover, not impossible that some sulphate of lead may fall when the acid liquor is diluted, and become mixed with the precipitated silver. It is not credible, however, that the lead in the coin can have been derived from the copper used to form the standard alloy, for this supposition would imply that copper of very inferior quality had been employed. According to Karsten,‡ copper which contains but one per cent of lead is utterly unfit for manufacturing purposes, since it cannot be worked at any temperature. Now the least amount of lead which we found in fifty cents' worth of American silver is 0.0253 gram. in 10 half-dimes of 1853. These 10 half-dimes contain 1.243 gram. of copper, and if this metal had been the source of the lead, it must have contained more than two per cent of that impurity.

We are ignorant of the process of preparing silver which was in use at the British Mint in 1816. Perhaps the silver in the coin of that date was obtained by cupellation, and it is well known that silver so obtained almost always contains lead.§

* D'Arcet, Journ. für tech. u. ökon. Ch., 1829, IV. 420.

† Quar. Journ. Chem. Soc. of London, 1857, IX. 289.

‡ In his System der Metallurgie, (Berlin, 1832,) V. 245.

§ Authorities differ as to the amount of lead contained in crude cupelled silver ("lightened silver," *argent éclairé*, *Blicksilber*). According to Berthier (Essais par la Voie Seche, (Paris, 1848,) II. 724), it contains, on an average, only 1 per cent of lead. Kerl (Handbuch der metallurgischen Hüttenkunde, (Freiberg, 1855,) III. 152), on the other hand, says that it contains from 5 to 10 per cent of impurity; and according to Karsten (System der Metallurgie, V. pp. 200, 201) *Blicksilber* contains at least 12 per cent of lead, and often more, the proportion of lead to silver being entirely dependent upon the temperature of the cupelling furnace. Since such silver is unfit for use, it is refined by small portions, either by a second cupellation at a high heat, or by melting it in crucibles with saltpetre and borax or some other flux (Kerl, *op. cit.*, III. pp. 181 to 198); but it appears to be impracticable, or at least not advantageous in practice, to remove the last traces of lead from the silver by either of these processes. (See Kerl, *op. cit.*, I. 224; or Plattner, Probirkunst mit dem Löthrohre, (Leipzig, 1853,) p. 403).

The silver of the Spanish and Mexican coins was doubtless prepared by the American system of amalgamation.* In this process, speaking in general terms, it would appear that silver is reduced by means of metallic mercury from a solution of chloride of silver in chloride of sodium, the amalgam which is formed being exposed meanwhile to the action of chloride of copper and perchloride of iron.

It is to be inferred from the investigations which we have cited, that under these circumstances the amalgam should be almost entirely free from any contamination with the more strongly electropositive metals.† It would seem, indeed, that the American system of amalgamation furnishes purer silver than is obtained by any of the other processes which are employed upon the large scale.

So far as concerns the occurrence of lead in the silver coin of our own country, it could probably be mainly, if not altogether, avoided, by employing zinc free from lead, such as is manufactured in Pennsylvania, as we have already described in our Memoir.

It is interesting to observe, that the occurrence of lead in some of the silver coins of the ancients‡ has been thought to indicate "that the process of separating lead and silver was less perfectly executed in the ages of antiquity than is at present the case."§ Yet, in none

* Described by Humboldt in his *Essai Politique sur le Royaume de la Nouvelle Espagne*, (Paris, 1811,) II. 558. See also Karsten, *Abhandlungen der phys. Klasse der Akad. der Wissenschaften zu Berlin*, 1828, p. 1; and Karsten u. Dechen's *Archiv für Mineralogie*, etc., 1829, I. 161; and again, *ibid.* XXV. 178, and in Dingler's *Polyt. Journ.*, 1852, CXXVI. 357. Compare the subsequent statements of Boussingault, *Ann. Ch. et Phys.*, 1832, [2.] LI. 350.

† In the European system of amalgamation, as practised at Freiberg in Saxony, where the silver is reduced from its chloride by metallic iron instead of quicksilver, a similar degree of purity in the silver is not to be expected. (For analyses of such silver, "Tellersilber," see Kerl, *op. cit.*, I. 234.)

‡ Walchner, *Schweigger's Journal für Ch. u. Phys.*, 1827, LI. pp. 204, 205. J. W. Draper, *Silliman's Am. J. Sci.*, 1836, [1.] XXIX. 160. Sarzeau, *Journal de Pharmacie*, 1839, XXV. 503. Brüel and Hausmann, Karsten u. Dechen's *Archiv für Mineralogie*, etc, 1844, XVIII. 505; also in *J. pr. Chem.*, XXX. 334. J. W. Mallet, *Trans. Royal Irish Acad.*, 1853, XXII. 319. Brüel and Hausmann refer also to earlier determinations of lead in antique coins by Klaproth (probably in his *Beiträge zur chemischen Kenntniss der Mineralkörper*, 1795–1780, B. VI.), and by Goebel (doubtless in his brochure, *Ueber den Einfluss der Chemie auf die Ermittlung der Völker der Vorzeit*, etc., Erlangen, 1842); but they do not indicate precisely where these analyses are to be found, nor have we any means of ascertaining this point.

§ Brüel and Hausmann, *loc. cit.*, *Archiv.* p. 509; *J. pr. Chem.*, p. 338.

of the recorded analyses of ancient silver coins to which we have had access have we been able to find that any one has detected so large an amount of lead in these coins, as we have shown to occur in American fine silver of the year 1860, if we except a single analysis by Professor Draper, who found nearly 3 per cent of lead in a silver coin of Hadrian. The greatest percentage of lead observed by Brüel (the author of the remark just quoted) was only 0.12. It is probable, however, that the methods of analysis — none of which are recorded — employed for separating lead from silver by the chemists to whose labors we have referred, were less delicate than the process which we have ourselves made use of.

It is interesting also in this connection to observe, that the American system of amalgamation, which at one time — before its peculiar fitness for the circumstances of the case in which it is employed had been recognized — was so frequently criticised by European metallurgists, affords silver which is less strongly contaminated with lead, and is probably purer in other respects, than is produced by any other process of manufacture.

II. *On the extreme Difficulty of Removing the last Traces of Carbonic Acid from large Quantities of Air.*

In the course of our research upon the impurities of zinc, we instituted a series of experiments, in order to ascertain whether the disagreeable odor of hydrogen gas, as generated from common zinc by means of sulphuric acid, could be attributed to the presence of any gaseous compound of carbon, — an apocryphal doctrine which seems to be quite generally credited.

The results of these experiments were entirely negative, in so far as they related to the point in question, and we should not have thought of publishing them, had it not been proved to us, by a memoir recently printed in Poggendorff's *Annalen*, that one of the phenomena which we then observed had not been sufficiently dwelt upon by chemists.

In our experiments above referred to, a jet of hydrogen was burned in a glass globe thirty centimetres in diameter, through which was drawn, by means of an aspirator, a steady current of air. Before entering the globe, this air had passed through an apparatus, described in full below, which was intended to deprive it of all its carbonic acid, and on leaving the globe it was drawn through a bottle containing

lime-water, carrying with it, of course, the products of the combustion of the hydrogen. We first used, in order to absorb the carbonic acid completely from the air in which the hydrogen burned, two cylinders twenty-seven centimetres high and five centimetres in diameter, filled with fragments of pumice-stone moistened with caustic potash; not satisfied with this large absorption surface, we next added to the cylinders two Wolfe bottles containing a concentrated solution of caustic potash, and finally substituted for the Wolfe bottles three five-bulb potash-tubes. We repeatedly maintained a burning jet of hydrogen in the globe for periods varying from four to six hours, with air purified by passing through the three potash-tubes and two cylinders described, and always obtained the same result; viz. there was never any perceptible cloud of carbonate of lime in the bottle containing lime-water during the progress of the experiment, but after standing twelve hours, an unmistakable deposit of crystalline carbonate of lime was invariably found at the bottom of the lime-water. We might have regarded this as sufficient evidence of the presence of an infinitesimal amount of carbon in the hydrogen, had we not found by repeated trials, that the burning of the hydrogen had no influence whatever on the formation of this crystalline deposit. 156,000 c. c. of air (the contents of our aspirator), passed through the purifiers we have described, still retained sufficient carbonic acid to produce a deposit of crystalline carbonate of lime, when allowed time to separate from the lime-water by crystallization.* In order to render the ex-

* The fact that carbonate of lime may at first be dissolved by lime-water, has been clearly shown by Vogel. (Schweigger's Journ. f. Ch. u. Phys., 1821, XXXIII. 207.) It is moreover very distinctly affirmed in the following passage from an article, which has recently fallen under our notice, by Berthollet (*Annales de Chimie*, 1789, III. 68):—"I am indebted to M. Welter for an observation upon the use of lime-water, which may be useful in cases where one wishes to detect small quantities of carbonic acid. Lime-water has the property of dissolving a little carbonate of lime, of which one can assure himself by blowing into it with a tube; the air expired produces a cloud which redissolves entirely, until the lime-water is saturated with the carbonate of lime which has been formed. If, therefore, it is desired to detect small quantities of carbonic acid by means of lime-water, it is necessary to agitate some carbonate of lime with the latter, in order that it may be saturated, before filtering it." That the carbonate of lime separates after a time from the lime-water which had previously held it in solution, has also been shown by one of us (*Am. J. Sci.*, 1858, [2.] XXV. 42), — at that time entirely ignorant of the experiments of Vogel and Welter.

periment irreproachable, with reference to the determination of carbon in the hydrogen, we should have been obliged to extend indefinitely our absorbing apparatus, and to force the air through the whole apparatus, instead of sucking it through, as in the experiments above described. The object in view was not worth such trouble and expense, and we moreover had not the necessary appliances, so that we were reluctantly forced to give up the inquiry.

Our interest in the subject has been awakened anew by some experiments recently published by H. Karsten,* upon the oxidation of dry non-nitrogenous organic substances by the action of atmospheric air at ordinary temperatures. The method upon which Karsten chiefly relied in these experiments was, in its essential features, identical with the one employed by ourselves, but the difficulty, to which we have referred, of removing carbonic acid from the air employed by any common absorption apparatus, is altogether ignored by him; † as will appear from the following description of his apparatus, quoted from page 349 of his article: "In order to purify from carbonic acid and water the air which I allowed to flow in a slow, continuous stream over the organic substances, I placed before the vessel which contained them chloride of calcium tubes several feet in length, and in front of these a tube containing dry caustic potash, preceded by a bulb-tube filled with concentrated solution of caustic potash; by this solution the air was first washed and freed from carbonic acid; it was then led slowly over the dry caustic potash and through the long chloride of calcium tubes, before it came in contact with the organic substances, which had been dried in the water-bath." It is evident, at all events, that this apparatus was far less adequate than our own for the difficult operation of removing carbonic acid from the air.

We do not in the least seek to deny the truth of Karsten's assertion, that carbonic acid is really formed by the action of air at ordinary temperatures upon the substances in question. The fact is not only probable *a priori*, but would seem to be proved by his incidental statement (p. 348), that carbonic acid was formed when these compounds (sugar, cork, &c.) were exposed during some months to the action of air or oxygen in tubes sealed with mercury in the pneu-

* Poggendorff's Ann. der Phys. u. Ch., 1860, CIX. 346.

† The reader of Karsten's memoir will observe that, like ourselves, he obtained for the most part only crystalline carbonate of lime, — no immediate cloudiness.

matic trough. In so far as charcoal is concerned, De Saussure* has long ago shown the extreme probability that it is oxidized by the air, even when dry, as it is when wet. Neither do we wish to assert that it is impossible to deprive air of every atom of its carbonic acid. We insist only upon the facts, that it is a matter of no inconsiderable difficulty to do this, that Karsten's apparatus was entirely inadequate, and that nothing in his paper would indicate that he has allowed for this source of error.

It should be distinctly borne in mind, that in the experiments of Karsten, as well as in our own, the question raised is not at all whether the amount of carbonic acid which escapes absorption can be estimated with the balance; for so long as the experiments are qualitative only, and conclusions are based upon the precipitate which is formed in lime-water, it is clearly necessary to remove every trace of carbonic acid from the air employed, no matter how "imponderable" this trace may be. We do not believe that the carbonic acid which escapes absorption in ordinary experiments can be of sufficient amount to be mentioned as a source of inaccuracy in the determination of the carbonic acid of the air, by the method which has been used by so many eminent chemists; for the extent of the error thus introduced must be far less than that of several others to which the absorption process, as commonly employed, is exposed, and which have been pointed out by Hlaziwetz,† and in part also by the brothers Rogers.‡

So far as we know, those observers who have previously touched upon this subject have been occupied with quantitative considerations only. They have, therefore, very properly rested content, when by experiment they have satisfied themselves that the last potash-tube of their series no longer increased in weight during the space of time occupied by a single experiment.§ It must, however, be evident to any one who will perform the experiment, that the presence of an amount of carbonic acid which could not be detected by any weighing of potash-tubes may readily be made manifest by precipitating it as *crystallized* carbonate of lime. In this connection it should be men-

* Gilbert's Ann. der Phys., 1814, XLVII. 119, note.

† Wiener Akad. Bericht, 1856, XX. 189.

‡ Am. J. Sci., 1848, [2.] V. 115; Edin. New Phil. Journ., XLIV. 150.

§ Compare, for example, Dumas and Stass, *Sur la véritable Poids atomique du Carbone*, Ann. Ch. et Phys., [3.] I. 18.

tioned that Brunner* has distinctly called attention to the extreme difficulty of completely absorbing carbonic acid from the air. Brunner could accomplish this neither by means of a solution of baryta, nor by a mixed solution of chloride of barium and caustic ammonia,† by bits of sponge moistened with baryta or lime-water, nor even by fragments of caustic potash, or asbestos moistened with a solution of potash; he finally chose slightly moistened hydrate of lime, as the best absorbent, and maintains that his method of determining carbonic acid in the air, by this means, is sufficiently accurate for all ordinary cases.‡

Professor G. P. Bond presented a memoir on the Light of the Moon and of the Planet Jupiter, containing the results of photographic and optical experiments upon the light of these two bodies.

The rays from Jupiter have been found to possess a remarkable degree of chemical energy compared with those reflected from ordinary opaque substances on the earth, and from the Moon; a similar excess

* Poggendorff's Ann. der Phys. u. Ch., 1832, XXIV. 571.

† Having had repeated opportunities of observing the great difficulty — not to say impossibility — of absorbing carbonic acid from mixed gases, especially if these contain so much as one or two per cent of it, by means of these and similar liquids, I am glad to bear witness to the entire accuracy of this much-neglected statement. — F. H. S.

‡ It is a curious fact, which not only corroborates Brunner's observation, but also suggests a more extended use in the laboratory of his favorite absorbent, that manufacturers of coal-gas find in practice, that carbonic acid, when not present in very abnormal quantity, may be readily removed from the impure gas by passing the latter through several layers of dry hydrate of lime, spread in fine powder upon perforated iron grates or upon shelves of basket-work ("dry-lime purification"); while it is practically *impossible* to absorb all the carbonic acid from similar gas by the wet system, in which the impure gas is forced through milk of lime contained and agitated in several successive purifiers. Yet with the other chief impurity of coal-gas, sulphuretted hydrogen, the reverse of this is the case, for by means of the wet-lime purification, this substance can, in ordinary cases, be very readily and completely removed with an expenditure of but little lime, while with the dry purification this result is far less easily attained. Moreover, this non-absorption of carbonic acid in the wet-lime purifiers cannot be due to any interference caused by the sulphuretted hydrogen, for it is just as difficult to absorb all the carbonic acid from rosin-gas, which contains no sulphuretted hydrogen, as it is to absorb that in the gas prepared from coal.

exists in the optical brightness of this planet. The chemical *albedo* of Jupiter, supposing the planet to reflect light after the usual manner of opaque substances, exceeds that of the Moon in the proportion of fourteen to one, the optical, in the proportion of eleven or twelve to one.

The experiments are open to the large uncertainties to which photometric comparisons are ordinarily liable; but, assuming their correctness, and that, as there is good reason to suppose, the proportion of sunlight incident on the Moon which is absorbed at its surface, compared with the amount reflected, is less than the smallest of the above-mentioned ratios, it would follow that the planet shines in part by native light, agreeably to the old notion of its phosphorescence. It is difficult to put any other construction upon the experiments, provided that Lambert's theory of the quantity of sunlight reflected to the Earth from a planet is applicable in the case of Jupiter. Perhaps a more acceptable explanation is, to suppose that its surface has the property of returning towards the Sun a disproportionate amount of the whole quantity reflected, taking ordinary opaque substances as a standard.

That this condition obtains with the Moon may be inferred from the fact, that at the full, the margin of its disk is brighter than the central regions, indicating a peculiarity in the constitution of its surface which would be likely to produce an excess of brightness at full moon. It is, moreover, placed beyond question from a consideration of the observed variations of the illuminating power of the different phases of the Moon, of which a detailed account is given in the memoir, — showing that the theoretical representations of the intensity of moonlight, in its changes from new to full and *vice versa*, as investigated by Euler and Lambert, bear no resemblance to the actual variations in the amounts transmitted to us. As Jupiter always presents a nearly full phase to the Earth, a similar property of reflection in its surface would tend to explain the anomaly. There is, however, this objection to that hypothesis: while the superior marginal brightness of the full Moon, whatever may be its cause, would naturally lead us to anticipate just that deviation from Lambert's theory of the amount of illumination derived from it which is actually observed to occur, the reverse order in the distribution of light over the disk of Jupiter, namely, its regular increase from the margin to the centre, in very good accordance with the same theory, is a strong argument for adopt-

ing the latter as properly applicable to the planet; in which case the explanation suggested would no longer be admissible.

According to the observations communicated, the light of Jupiter, seen from the Earth at its mean opposition, is to the light of the mean full moon as 1 : 6430. Compared with the light of Venus at its greatest brightness, it is as 1 : 4.864.

Professor Bond also read a memoir on the relative brightness of sunlight and moonlight.

Of the results given by Bouguer and Wollaston, for the proportion between sunlight and the light of the full Moon, viz. :

Bouguer	.	.	.	.	.	.	$s = 300,000$
Wollaston	.	.	.	.	.	.	$s = 801,072$

the preference has been generally given to the latter. Reasons are adduced in the present communication for considering Bouguer's method of observation to be the best of the two, and his results deserving of most confidence. Comparisons, by means of Bengola lights, of the images of the Sun and Moon reflected from a silvered globe, give the value,

$$s = 471,000.$$

Other methods, less reliable, also tend to confirm Bouguer's determination.

Professor Bond also communicated a Catalogue of Stars near the Zenith of the Observatory of Harvard College, collected from the best existing authorities, having for its object to furnish to astronomical surveyors in the region of the Great Lakes and elsewhere, nearly in the same parallel, accurate star-positions for the determination of latitude by the zenith telescope.

Professor Agassiz discoursed upon the application of his principles of classification to the systematic arrangement of Polyps.

Professor Cooke, announcing the favorable result of his recent personal application, in behalf of the Academy, to the Royal Astronomical Society, the Geological Society, and the Museum of Practical Geology, London, to supply deficiencies

in the Academy's set of their publications, moved, and it was voted, —

“That the special thanks of the Academy be presented to these institutions for their marked interest and courtesy in this behalf, and for their very valuable gifts.”

Mr. Thurber of New York, by permission of the Academy, exhibited an ingenious adaptation of the pantograph, by which partially paralytic persons, unable to write in the ordinary way, may write with great facility.

Four hundred and eighty-seventh meeting.

October 9, 1860. — MONTHLY MEETING.

The PRESIDENT in the chair.

Dr. Hayes, in presenting a “Report on supplying the City of Charlestown with pure Water, made by Order of Hon. James Dana, Mayor, by Messrs. George R. Baldwin and Charles L. Stevenson, Civil Engineers,” remarked, that

Chemical analysis presents points of interest relating to the composition of the water of Mystic Pond. The results obtained on carefully selected samples of this water, recorded in the Report, show a great variation existing at different parts of the mass of water. The weights of solid matter found in a standard gallon, are 4.08 gr., 4.64 gr., 15.52 gr., 16.88 gr., and 58.64 gr. Below a certain depth, the nearly pure water of this pond reposes on a heavier saline water. Further observations have shown that this saline water, closely resembling sea-water, maintains a nearly constant level in relation to the purer water reposing on it, and that the saline diffusion is apparently very slight in amount, or very slow in point of time. Change of temperature does not cause an intermixture of the two kinds of water; as the lower stratum has a density superior to that of the pond-water at its greatest density, and, physically, the conditions of repose are nearly the same, so far as penetration is concerned, as if a saline sand-bottom held the place occupied by the heavier water.

This pond, containing two kinds of water, can support the plants and animal organisms of fresh water and of ocean water at the same time.